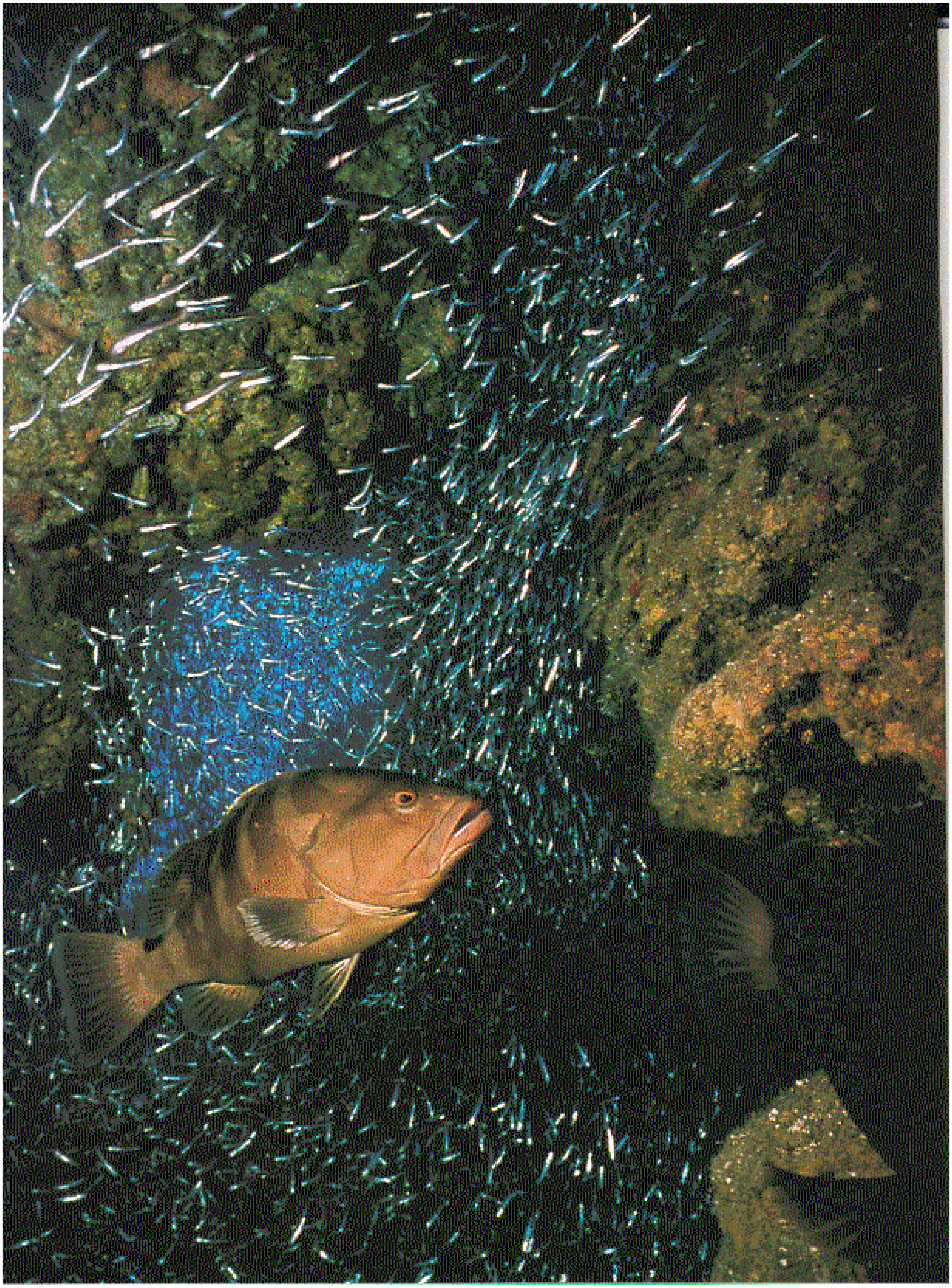


Sustainable Fisheries

From the Gulf of Alaska to Gulf of Maine, NURP scientists are descending in undersea vehicles to study the world's most productive fishing grounds. Through the viewport of a submersible, NURP scientists observe where and how fish live and record more precisely how many fish exist at these depths. While important harvested species are in decline, their recovery may be impeded because their habitats are threatened by human activities as well as other factors. This information is of increasing interest to fisheries managers who consider essential habitat a critical factor in protecting marine resources and as a resource to be managed. Fisheries management and conservation also depends on knowing what naturally regulates the abundance of marine fishes.

This chapter focuses on identifying the key habitats of critical species, and what physical and biological processes are responsible for their survival and sustainability.

Nassau grouper.

Fishing Gear Impacts

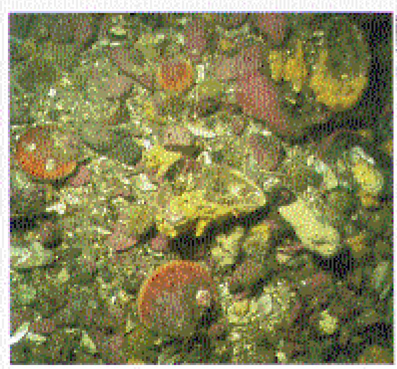
From the Gulf of Maine to the Gulf of Alaska, researchers are descending in undersea vehicles to study remote and rugged environments where important fish stocks live. Some of these fish–cod, flounder, and grouper to name a few–are in decline. Their recovery may be impeded because their habitats have been degraded or destroyed by human influence. Just as some animals take refuge in the African prairie grass to hide from lions, some marine fish take refuge in places like coral reefs, shipwrecks, sea grass, worm tube mats, sponge-covered gravel, forests of anemones, or mud burrows to hide from bigger fish. Computer models indicate that reductions in habitat complexity reduce survival of juvenile fish, especially during periods of low population size.

In several recently funded NURP studies, fisheries biologists have been trying to determine the effects of fishing and fishing gear on juvenile fish habitats and on the survival of harvested species that live within the U.S. Exclusive Economic Zone. Submersible vehicles have given these scientists more precise estimates of fish abundance and habitat requirements.

In the Gulf of Maine, mobile fishing gear has reduced seafloor habitat complexity, according to Peter Auster, a NURP fish ecologist. Auster and colleagues from the Sea Education Association, University of Maine, Maine's Department of Marine Resources and U.S. Geological Survey in Woods Hole used a remotely operated vehicle (ROV), submersible and sidescan sonar to study the impacts of trawling on habitat. The researchers found that trawling reduces habitat complexity by removal of benthic fauna such as sponges, smoothing of sand ripples, and removal of species like crabs that produce depressions and burrows. Fishing gear impacts also reduced biodiversity, which may alter the number and variety of species in a community. The effects of these disturbances to the food web, and to fish production, can only be roughly predicted, Auster said.

Continued studies during the past two years have focused on NOAA's Stellwagen Bank National Marine Sanctuary. Auster and his colleagues used an ROV to link fish distributions to a range of underwater habitats. The fish and the different kinds of seascapes they live in were identified using multi-beam bathymetry and sidescan sonar. Habitats, based on their ecological value to fishes, were then classified by researchers to provide a baseline of information for a long-term habitat monitoring program at the sanctuary. These studies have raised further questions about the amount of fishing effort required to change habitat integrity for particular species, and what kinds of measures could be used for repairing habitat damage in the future. "Understanding how fishes, especially juveniles that are more vulnerable to predators, use particular habitats leads us to an understanding of how to manage habitat for sustaining harvested fish populations, as well as the related objective of sustaining biodiversity of non-harvested species," said Auster.

To better determine the impacts of scallop dredging on the fish habitat of Northeastern Georges Bank, a multi-year NURP study by



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Examples of disturbance to the seafloor produced by a single pass of a scallop dredge at a coastal site in the Gulf of Maine (20 m depth). The images are before and after images from a cobble-shell habitat. The sponge colonies that stabilize the shell aggregates are removed in the impacted state.


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Red fish.

researcher Jeremy S. Collie of the University of Rhode Island is now in place. A stark contrast was observed at undredged sites versus dredged sites by Collie. Undredged sites were composed of hydrozoans, bryozoans, and tube-dwelling polychaetes called epifauna, which make complex habitats for small animals. At dredged sites, epifauna and small animals are almost entirely absent, and predators and scavengers are abundant, Collie said. In a heavily disturbed area of Georges Bank, which had been closed to fishing since December 1994, there were initial signs of recovery, according to Collie's observations during 1996 and 1997. New colonies of epifauna had emerged and juvenile scallop populations were on the increase. This year, Collie will use side scan sonar, video, and still photographic imagery of the seafloor to continue to document the recovery of the area closed to fishing compared with areas where bottom fishing continues.

Historically, clam dredge surveys have been used to describe the habitat requirements of fish and shellfish and quantify their abundance. The results of these surveys produce mixed results with only a very broad determination of fish distributions, variances in estimates of mean abundance, and inadequate sampling of recently settled juvenile fish, said Robert Cowen, a fisheries biologist of the State University of New York at Stony Brook.

Last summer, NURP provided some valuable undersea research tools for evaluating the efficacy of hydraulic dredging used in stock assessments for commercially important species of clams.

"There had been suggestions that hydraulic dredges used to contact clam stock assessment surveys weren't working the way they were supposed to to catch clams,"said Waldo Wakefield, a fisheries biologist with NURP's Mid-Atlantic Center. During a stock assessment of two valuable commercial clam species, surfclams and ocean quahogs, in the New York Bight by NOAA's National Marine Fisheries Service's (NMFS) Northeast Fisheries Science Center last summer, Wakefield helped facilitate the center's use of some new undersea sensors to insure the clam dredge was doing its job. Technology developed by NMFS, including an inclinometer for measuring whether the dredge was making contact with the bottom, as well as video cameras for monitoring the dredge's performance, was used in the New York Bight.

"Sometimes a picture is worth a thousand words," Wakefield said. The *in situ* sensors allowed fisheries managers to quantify the performance of the dredge, while the overall operation of the dredge was monitored by an undersea video camera along for the ride recording footage of the dredge in operation.

The effects of fishing can have a more serious impact. In the Caribbean, Florida, and the Gulf of Mexico, anglers have learned where and when to find grouper spawning aggregations. These fish do not spawn continuously, so wiping out an aggregation may eliminate a whole generation of fish in a region. In 1994, this targeted fishing prompted the South Atlantic Fisheries Management Council to set aside a no-fishing zone in the Oculina Reserve (named for its oculina corals) off southeastern Florida. In 1996, using a NURP-supported submersible and side-scan sonar, fisheries biologists Churchill Grimes of the National


CMRC

Black volcanic sponge.

Marine Fisheries Service in Panama City, Fla., and Chris Koenig of Florida State University, surveyed and described fish distributions and habitat conditions in the Oculina Reserve. Most reef fish dependent on the Oculina coral for habitat, including snowy grouper, black sea bass, and amber jack, suffered a drastic reduction since the sites were surveyed a decade ago, the scientists observed. In addition, coral had been heavily damaged from trawling and dredging. Where some dense branches of coral once stood a foot tall, all that remained was rubble and thumb-sized coral. In 1999 and beyond, new technologies such as laser line scan systems will provide faster, better habitat surveys to aid their long-term monitoring efforts.

Shellfish and Fish Habitat

Invertebrates that grow on cobbles and boulders also provide cover for juvenile fish and shellfish such as cod and lobster. Today, lobster is the single most important regional commercial species in the northeast United States. Lobster grosses more than 100 million dollars in landings and employs 10,000 lobstermen in the State of Maine alone. Overfishing and fish nets dragged along shallow cobble bottoms in the Gulf of Maine–the only habitat where New England lobsters have their nursery grounds–threaten the lobster harvest. By counting the number of baby lobsters that have just arrived there, fishermen have a good estimate of what landings will be like for the next seven years, said Robert Steneck, a marine biologist at the University of Maine.

Steneck, who studies the complex life cycle and ecology of lobsters, has used NURP support, submersibles, and scuba diving, to observe the habitats that lobsters occupy during different stages in their life. From cobble nursery grounds, juvenile lobsters move to boulder fields and kelp beds, and then as mature adults to deep waters offshore. Oceanographic circulation patterns, observations by lobstermen, and data from NMFS support the hypothesis that reproductive age lobsters are concentrated in near-shore, deep-water habitats in the northeast corner of the Gulf of Maine. Finding out where lobsters live is one of the mysteries researchers set out to solve with NURP support in 1997. The *Johnson-Sea-Link* submersible enabled Steneck to observe lobsters directly in their range of habitats throughout the Gulf of Maine. The work augmented traditional stock assessment approaches, and confirmed that significantly more lobsters live nearshore in deep waters off the eastern Maine Coast than previously thought.


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The lobster's life history remains a mystery.

Still, parts of the lobster's life history remain a mystery. Lobsters are the only fishery in the world that has been aggressively harvested for more than a century and has not only remained stable, but stocks have increased. "One theory is that the lobster broodstock are living in a refuge," Steneck said, "relatively immune to being harvested. This would explain why the resource, harvested for the past 150 years, has been stable or has increasing populations." If the refuge where the reproducing broodstock lives can be identified, fisheries managers have a better chance of protecting it, he added. An earlier project to quantify the abundance and location of reproductive lobsters by Steneck led to the discovery that a segment of lobsters that live on Georges Bank have migrated there from other habitats as far away as Nova Scotia and New Hampshire. *In-situ* studies to piece together the life history phases of the lobster along with the physical oceanography of the Gulf of Maine present a unique opportunity to understand one of our important marine resources, Steneck said.

NMFS biologist Mary Yoklavich used the *Delta* submersible, a two-person shallow diving submersible that dives to 370 m (1,200 ft), to explore rockfish living in the rocky outcroppings of Monterey Bay, California. Rockfish, named for their preferred habitat, are one of the most popular commercial and recreational fish on the west coast. They also fascinate fisheries biologists because of their diversity and longevity–there are 57 species of rockfish on the west coast alone, and some can live to be more than 100 years old. Their longevity, late maturation, and rugged habitat make them difficult for fisheries managers to assess and manage. Yoklavich used sidescan sonar to precisely describe the seafloor in portions of Monterey Bay canyons, and video cameras mounted on the submarine to count cryptic rockfish tucked in canyon walls. What Yoklavich found was an astonishing population of rockfish that far exceeded the rockfish populations living in more exposed canyons exploited by fishing. The habitat appeared to provide rockfish with greater protection from fishing. Fisheries biologists Victoria O'Connell of the Alaska Fish and Game, NURP's Waldo Wakefield, and Gary Green of Moss Landing Marine Laboratories used similar techniques to census rockfish habitat along the Alaska coast with NURP funding.

Rockfish.

NURP-funded oceanographer Eric Vetter of the Scripps Institution of Oceanography also discovered that habitat plays a role in fish abundance during his study of microbial food webs in Scripps Canyon off the coast of La Jolla in southern California. Using the *Delta* and the submersible *Sea Cliff* in 1996, Vetter found significantly more fish including sablefish, dover, sole, and Pacific hake at all depths inside the canyon than outside the canyon. A slurp gun attached to the submersible vacuumed up samples of kelp, surf grass, and detritus accumulating in the canyon, which appear to support the smallest organisms at the base of the food chain that larger fish need to survive, Vetter said.

With the recent advent of manned submersibles and ROVs equipped with high resolution cameras, the problem of collecting data on juvenile fish has improved, Auster said. In a two-year study beginning in 1997, fisheries biologists Cowen and Kenneth Able of Rutgers University Marine Field Station received NURP support to evaluate what habitat qualities are critical for juvenile fishes living in shell beds off New Jersey. By conducting surface trawl efforts in combination with *in-situ* observations, the researchers have a powerful tool for estimating juvenile fish densities in association with specific habitats, information local fishery managers use to protect the fishery. The results of the project will also be used to help evaluate the potential impact of fishing practices, such as scallop trawling, on benthic community structure.

Based on the evidence that habitat plays an important role in fish abundance, some fisheries biologists are recommending a different management approach, which is prompting action by some fisheries management councils. Auster and his colleagues have been advocating use of a precautionary approach to habitat management. Setting aside no-fishing areas in all habitat types from mud to boulders would enable assessments of the effects of fishing on habitat resources.

"Our management of marine resources has to go beyond looking at the abundance fluctuations of species,"Cowen said. "We have to look at the entire marine ecosystem, and part of that is habitat." All of the Fishery Management Councils will be addressing the need to designate and conserve essential fish habitat as mandated under the Sustainable Fisheries Act. NURP-supported research will be used in making these decisions. The challenge will be to not only translate the results of completed research into useful information for fishery managers, but to continue to fund high quality studies that support management needs into the future.